

## Description

# A simple, compact and effective self-extending and retracting bicycle crank arm

### BACKGROUND OF INVENTION

[0001] This invention relates to a bicycle crank and pedal assembly and, more particularly, to an assembly with a self-extending and retracting crank arm.

[0002] The length of the crank arm in a bicycle is a compromise between performance and comfort. A longer arm allows a cyclist to travel at the same speed with a lower pedal effort or a slower pedal turning rate, or both. However, the longer arm increases the size of the pedal track round the crank axle and causes discomfort to the leg. One method to get the benefit of a longer arm without getting the discomfort is to extend the arm beyond the compromised length during the pedal power down stroke and retract it below this length in the return upstroke.

[0003] Using a longer crank arm is not equivalent to using a

lower gear ratio in cycling. A lower gear ratio allows the cyclist to travel with a lower pedal effort. However, it also requires the cyclist to turn the pedal at a higher rate in order to travel at the same speed.

[0004] Crank and pedal assemblies with self-extending and retracting crank arms have been described by Chattin (US Patent Number 4446754, 4519271), Xi (4706516), Stuck-enbrok (4807491), Trevizo (4882945), Sander (4960013), Fortson (5095772), Garneau (5207119), Ticer and Farney (5261294), Yan and Kim (5553515), Wan (5566590), De-bruin (5879017), Kang, Kim and Park (6152471, 6508146), Harrington (6199449, 6276234) and Farney (6474193). These assemblies have many notable deficiencies. Firstly, they are ineffective in delivering the benefits of a self-extending and retracting crank arm, because they only have one arm position with a fully extended arm. For all other positions, the arm is either extending or retracting. Secondly, compared with the standard assembly in a bicycle, many are bulky and have noticeably reduced clearances between the crank arm and the leg. Thirdly, many also have more than twice the number of components moving relative to each other, components moving too close to the leg, components that could wear

out prematurely, or high frictional loss.

## SUMMARY OF INVENTION

- [0005] This invention is a bicycle crank and pedal assembly with a self-extending and retracting crank arm. The assembly only has the following three one-piece components that move relative to each other, if the bearings used in friction reduction are ignored:
- [0006] 1. A crank arm that has a cavity for a rotating plate as well as a track for a device to move back and forth along the length of the arm,
- [0007] 2. A device that moves on a track in the crank arm and has a pedal spindle fixed to it at one end, and
- [0008] 3. A subassembly in which a plate and a pedal are fixed to the opposite ends of a plate shaft.
- [0009] The pedal spindle and the plate shaft are coaxial. One of them has a cylindrical hole for the other to pass through. During cycling, the pedal rotates the plate inside the plate cavity in the crank arm and modulates the distance between the plate shaft and the crank axle in a prescribed manner. This distance is the effective length of the crank arm.
- [0010] In the crank arm extension phase that begins with the arm at the 12 o'clock position, the plate or the foot works with

centrifugal force to increase the effective length of the crank arm by moving the plate shaft away from the crank axle. After the extension, foot motion and gravity maintain the length at the maximum value. In the retraction phase that begins with the crank arm at the 6 o'clock position, the plate, foot and crank arm rotation combine to reduce the effective arm length by moving the plate shaft closer to the crank axle. After retraction, the foot and gravity maintain the length at the minimum value until the crank arm returns to the 12 o'clock position.

[0011] This invention differs from those in the references cited in that the crank and pedal assembly is simple, compact and very effective in delivering the benefits of a self-extending and retracting crank arm. In particular, it delivers (a) the maximum effective arm length for over 90 degrees of arm positions in the power down stroke and (b) the minimum effective arm length for close to 90 degrees of arm positions in the return upstroke.

#### **BRIEF DESCRIPTION OF DRAWINGS**

[0012] Fig. 1 is a view of the crank and pedal assembly with the crank arm at the one o'clock position. The lines on the side of the crank arm indicate the locations where the arm would be cut to produce an exploded view of the assem-

bly.

- [0013] Fig. 2 is an exploded view of the assembly shown in Figure 1. The crank arm has been cut into five slices labeled as slices 2A–2E.
- [0014] Fig. 3A shows a sectional view of the assembly in the horizontal plane through the plate shaft in Figure 1.
- [0015] Fig. 3B shows the three one-piece components of the crank and pedal assembly in Fig. 3A.
- [0016] Fig. 4A shows a sectional view of the assembly in the plane through the plate shaft and the crank axle in Figure 1.
- [0017] Fig. 4B shows the three one-piece components of the crank and pedal assembly in Fig. 4A.
- [0018] Figs. 5A–5D show the sectional views of the assembly in four vertical planes through the crank arm and perpendicular to the plate shaft. The planes pass through the centers of slices 2B–2E, respectively, in Fig. 2.
- [0019] Fig. 6 shows the positions and orientations of the plate, plate cavity, plate shaft and the outline of the slit in slice 2C for eight different crank arm positions.
- [0020] Fig. 7 is an explode view of the crank and pedal assembly in a second embodiment of the invention. The crank arm has also been cut into five slices labeled as slices 2A–2E.

[0021] Fig. 8A shows a sectional view of the assembly in the horizontal plane through the plate shaft in the second embodiment.

[0022] Fig. 8B shows the three one-piece components of the crank and pedal assembly in Fig. 8A.

#### **DETAILED DESCRIPTION**

[0023] The crank and pedal assembly on the right hand side of a bicycle is described in detail here. A description of the assembly on the other side is unnecessary, because this assembly is a mirror image of the one on the right.

[0024] Three embodiments are presented. The second and the third are included for the sake of completeness only.

[0025] *First Embodiment*

[0026] Figure 1 shows a view of the assembly with the crank arm at the one o'clock position. The visible components are the crank axle 1, crank arm 2, pedal 4, plate shaft 5, and a slit 3 in the crank arm 2. The end of the plate shaft is drawn with a square cross section to indicate that the pedal does not rotate about the shaft. The lines on the side of the crank arm show the locations where the arm would be cut to produce an exploded view of the assembly.

[0027] Figure 2 shows an exploded view of the assembly shown in Figure 1. The crank arm has been cut into five vertical slices denoted by slices *2A–2E*. Slice *2A* is the back of the crank arm. Slice *2B* has a cavity *6* for holding the plate *7*. To avoid confusion, the line to the cavity has been terminated at the edge of the cavity. Slice *2D* has a track *9* for the movable device, which is in the form of a bar *10* with a pedal spindle *11* fixed to it at one end. The spindle *11* has a cylindrical hole along its length for the plate shaft *5* to pass through. Slices *2C* and *2E* combine to keep the bar in the track *9* and to resist the tilting force the pedal *4* applies to the plate *7* and the bar *10* in the power down stroke. They have slits *8* and *3*, respectively, for the plate shaft *5* and the pedal spindle *11* to pass through. The main body of the plate shaft *5* is a circular rod. One end of the shaft *5* is fixed to the pedal *4*. The other end is inserted into the hole in the pedal spindle *11* and then fixed to the plate *7*. The pedal end of the plate shaft *5* has been drawn as a rectangular block, to indicate that the pedal *4* does not rotate about the shaft *5*.

[0028] Figure 3A shows a sectional view of the assembly in the horizontal plane through the plate shaft *5* in Figure 1. The directions of the front and the back of the bicycle are

marked. Figure 3B shows the three one-piece components of the crank and pedal assembly in this view. The first one-piece component is the crank arm 2, which has the plate cavity 6, bar track 9, and arm slits 8 and 3. The second is the bar 10 with the pedal spindle 11 fixed to it at one end. The third is a subassembly in which the plate 7 and the pedal 4 are fixed to the ends of the plate shaft 5. The pedal spindle 11 has a cylindrical hole for the coaxial plate shaft 5.

[0029] Figure 4A shows a sectional view of the assembly in the plane through the crank axle 1 and the plate shaft 5 in Figure 1. Figure 4B shows the three one-piece components of the crank and pedal assembly in this view.

[0030] Figures 5A–5D show four sectional views of the assembly in planes perpendicular to the plate shaft 5. Figure 5A is in a plane through slice 2B and the plate 7. It shows the shapes of the plate 7 and the plate cavity 6. The black dot in the plate 7 is the plate shaft 5. Figure 5B is in a plane through slice 2C. It shows the shape of the slit 8, which is located between the plate 7 and the bar 10. The black dot inside the slit is the plate shaft 5 and the circle centered at the dot is a cross section of the pedal spindle 11. Figure 5C is in a plane through the bar 10. This bar is pushing

forward and downward against the track 9 in slice 2D. Figure 5D is in a plane through slice 2E. Slit 3 has the same shape as the slit 8 in slice 2C.

[0031] Figure 6 shows the positions and orientations of the crank arm 2, pedal 4, plate shaft 5, plate cavity 6, plate 7 and arm slit 8 for eight crank arm positions. The pedal 4 is represented by a line, so that it does not block the objects behind it. The plate 7 tilts with the pedal 4, because the plate 7 and the pedal 4 are fixed to the plate shaft 5. The slit 8 and plate cavity 6 rotate with the crank arm, because they are holes in the crank arm. The cranks arm on the right hand side of a bicycle rotates clockwise during pedaling. This figure shows that the crank arm has (a) the maximum effective length for over 90 degrees of arm positions in the power down stroke and (b) the minimum effective length for close to 90 degrees of arm positions in the return upstroke.

[0032] During the crank arm extension phase that begins at the 12 o'clock arm position, forward foot motion and centrifugal force increase the effective length of the crank arm by pushing the plate shaft 5 away from the crank axle. The plate 7 only prevents the effective arm length from falling below a specified value. At the end of exten-

sion phase, foot motion and gravity keep the distance at the maximum value. In the pedal return upstroke that begins at the 6 o'clock arm position, the plate 7, foot and clockwise rotation of the crank arm 2 combine to push the plate shaft 5 closer to the crank axle 1. After retraction, foot motion and gravity keep the effective arm length at the minimum value until the crank arm returns to the 12 o'clock position.

[0033] *Second Embodiment*

[0034] The second embodiment is obtained from the first by exchanging the positions of the bar 10 and slice 2D with those of the plate 7 and slice 2B, respectively. Figure 7 shows an exploded view of the new crank and pedal assembly after the exchange. The crank arm is at the one o'clock position. Figure 8A shows a sectional view of the new assembly in the horizontal plane through the plate shaft 5 and Figure 8B shows the three one-piece components of the assembly in Figure 8A. The pedal spindle 11 in this embodiment is solid and the plate shaft 5 has a cylindrical hole for the spindle 11 to pass through.

[0035] *Third Embodiment*

[0036] The third embodiment is obtained from the first by delet-

ing the plate and the plate cavity, i.e., deleting the plate 7 and slice  $2B$ , from the design. Its effective arm lengths in the 12–3 o'clock and 6–12 o'clock arm positions depend on the foot motion of the cyclist.